Adapting the Process: *Managing Large Complex Systems*

Presentation to the
Army Acquisition Senior Leaders' and

AMC Commanders' Conference 2005

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25 August 2005

MITRE

Agenda

- Mega-Systems
- Case Studies
- Implications for Systems Engineering
- Implications for Spiral Development

Operation Enduring Freedom: *an Early Glimpse of the Future*

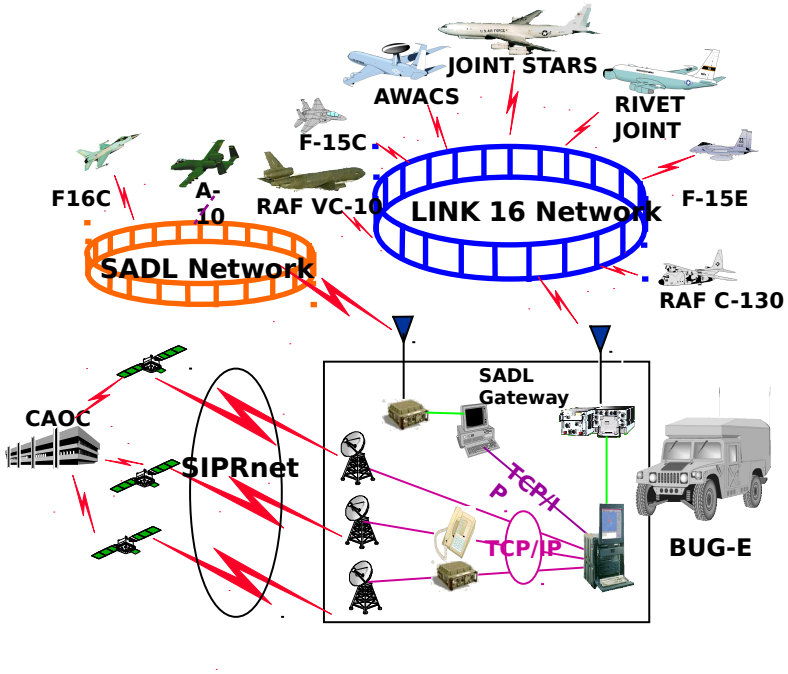
nprecedented Collaborative Engagement with Networked Forces

- **SOF forces request close air support (CAS)**
- **F-14 providing CAS out of weapons**
- **F-14 crew employ onboard sensors to mensurate target**
- **Crew passes target data (via voice) to AWACS**
- **B-52 enables successful target kill with precision munitions**
- **Time to target: 18 minutes**

- ***No requirement or architecture anticipated it***
- ***Not achieved by any single system***
- ***May never happen again in exactly the same way***

Western Iraqi Theater

- Existing C2 systems connected by new gateways (BUG-E)
  - Received feeds from Link 16, SADL and BFT equipped forces (inc. SOF)
  - Translated
  - Any SADL, Link 16 equipped AC or anyone with SIPR connection could access
- "Came up with targets on the ground… passed them through targeting systems… put them on the Link 16… moved them to SADL… and then to the aircraft HUD"



A little innovation that had a large pay-back

Source: OFT Case

A Trend Towards Larger, More Complex Systems

- **Uncertain strategic environment demands agile/adaptive responses**
- **Information as competitive source of power**
- **Demand for enterprise and extended enterprise-wide solutions**

- **Richly *interconnected*; increasingly *interdependent***
- ***Cross traditional boundaries…* functional, organizational, programmatic**
- ***Increasing scale/scope***
- ***Increasing complexity***

"Mega-systems"

Changing Context: *Increasing Uncertainty, Complexity and Diversity*

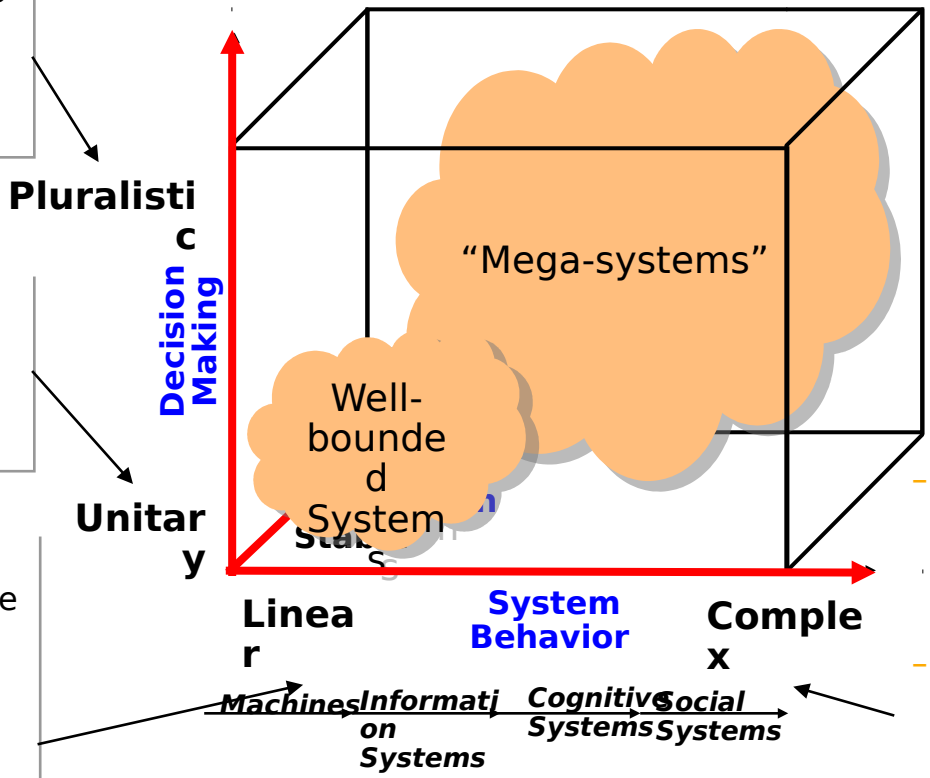
- Little or no agreement as to common goals and objectives; decision makers focus on *local concerns*

- *Agreement* as to the goals and objectives; decisions are made and implemented WRT common goals

- Behavior is regular, well understood and, to a large extent, *predictable*

- Relatively closed to the environment

- Components not purposeful; exist only as part of larger system



- Not all behavior directly observable; not all interactions well understood

- Do not necessarily follow predictable rules of behavior; solutions to specific problems may have totally unexpected consequences

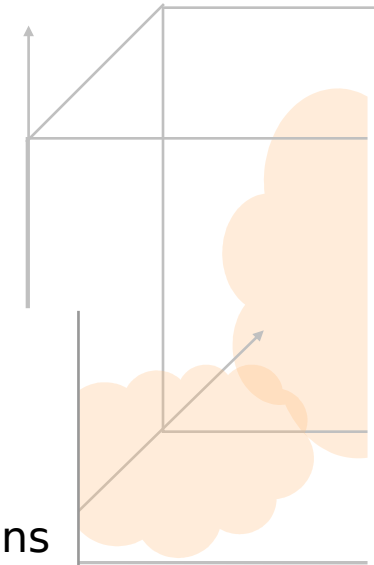
- Interact with environment and evolve

Mega-systems: "*large-scale, potentially complex systems that cross traditional boundaries to provide capability beyond that achievable by their component elements*"

… Suggests Different Approach

Traditional Program

- Predicated on well-defined, precise, and stable requirements
- Assumes that overall functions can be decomposed and allocated
- Manages execution risk



Mega-System

- Requirements often stated as vision statements or broad architectures. *Evolve opportunistically*
- Some functionality will emerge from interaction of components without specific direction
- Manage uncertainty – both risk and opportunities
- Often cross program boundaries; must deal with competition for resources and alternative solutions

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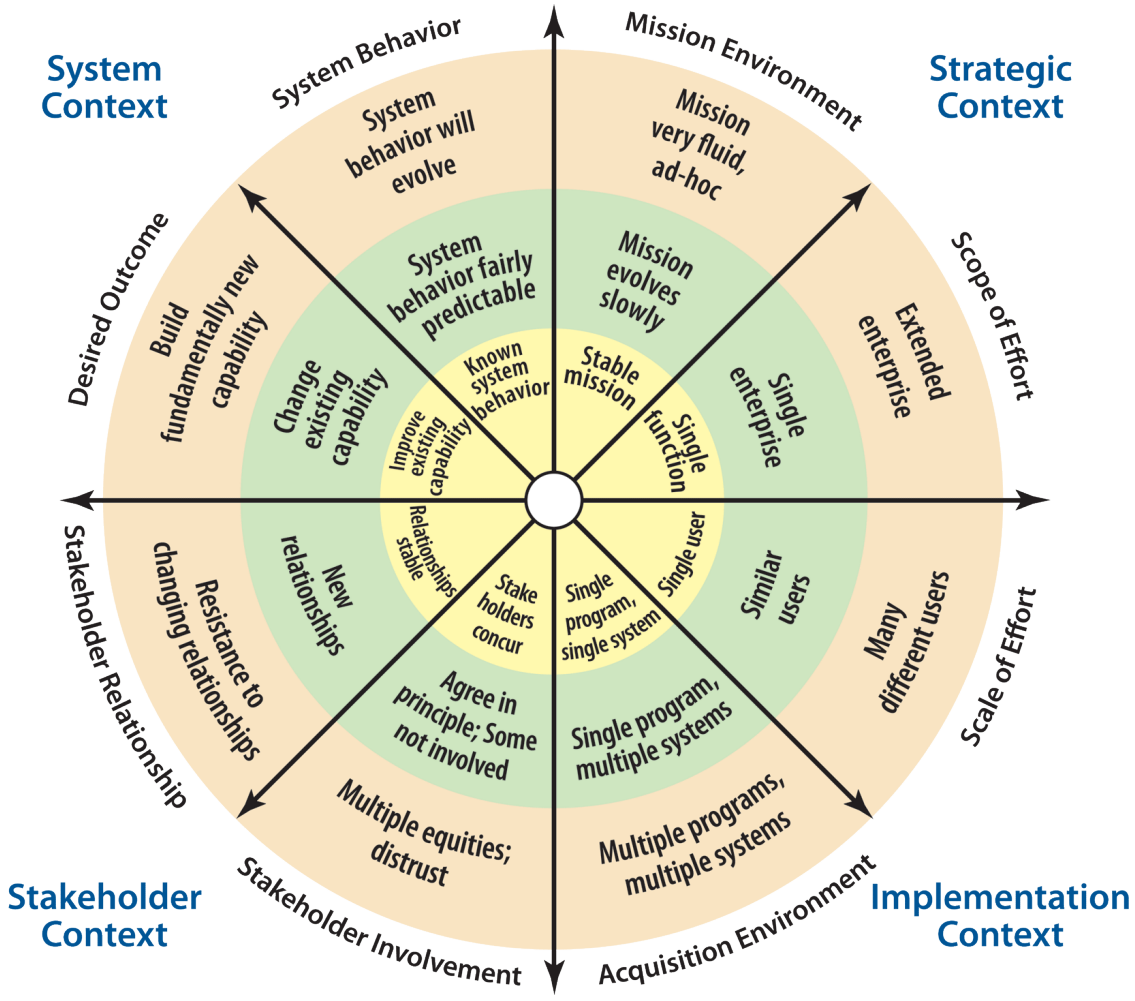
- Insights from Case Studies
- Implications for Systems Engineering
- Implications for Spiral Development

What Seems to Work And Not So Well…

- The enablers
  - (Some) architectures, visions, engineering master plans…
- Continuous, broad-based involvement
  - Representatives from different organizations actively involved
  - Visible senior leader support
- Consensus around infrastructure and tenets
  - Open standards
- Guided, incremental developments
- Integration facilities (virtual and real)
- Experimentation, early field trials
- Response to real crisis
  - Overcome “tribal” tendencies
- Charismatic “champion” that can overcome process limitations

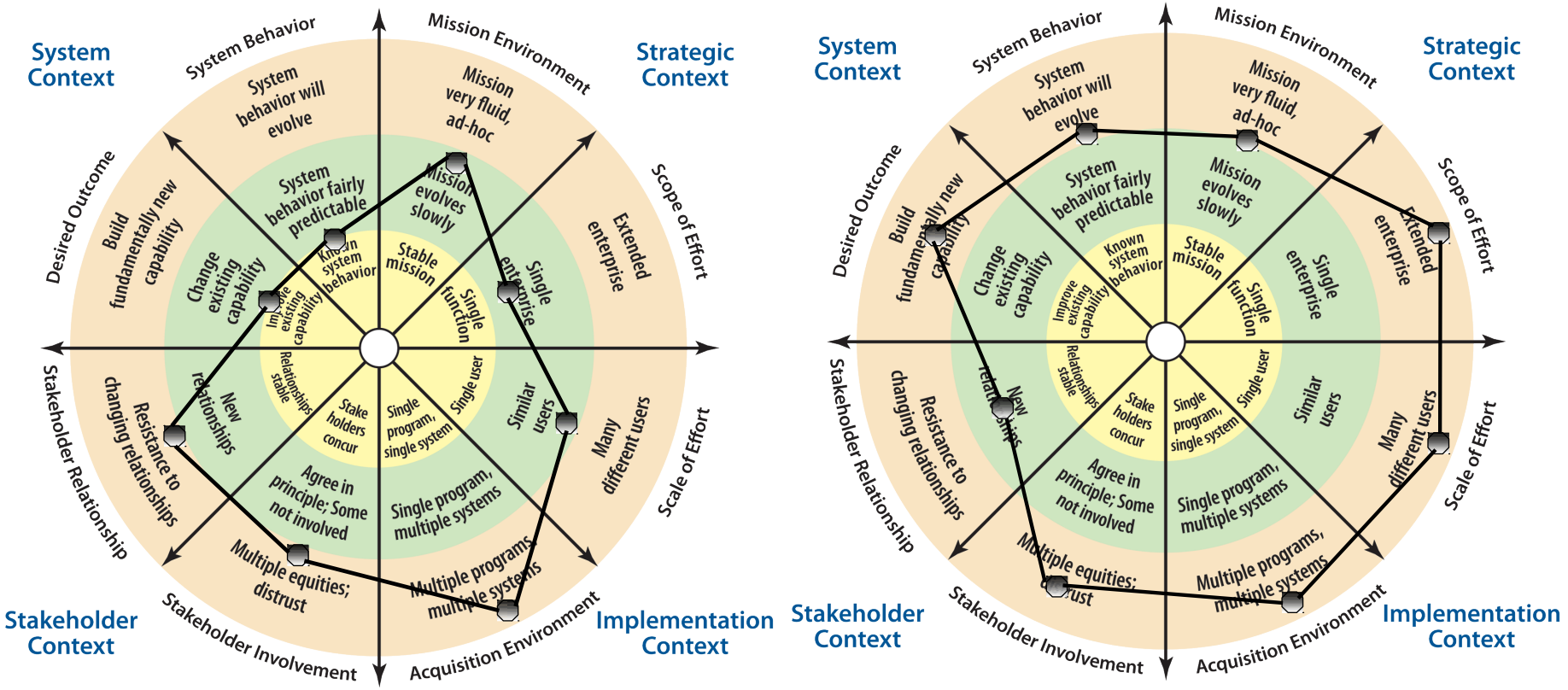
- Requirements and specs
  - Difficult to articulate how parts will work in context of the whole – lack lexicon
  - Desire for global specificity and completeness
- Multiple stakeholders, overly complex organizations
  - Separate agendas, distrust…
  - Process takes precedence
- Dealing with uncertainty
- Grand design
- Too long a horizon
  - Technology changes, expectations change, users change…
- Too narrow a view
  - Ignoring some key stakeholders
  - Technical solutions for non-technical issues (e.g., privacy)
- Acquisition across boundaries

Emerging Framework



- **Traditional program domain**
  - ***Well-bounded problem***
  - ***Predictable behavior***
  - ***Stable environment***
- **Transitional domain**
  - ***Systems engineering across boundaries***
  - ***Influence vs. authority***
- **Messy frontier**
  - ***Political engineering (power, control…)***
  - ***High risk, potentially high reward***
  - ***Foster cooperative behavior***

… Applied to Two Case Studies



- **Government effort**
- **To ensure consistent processing logic across multiple platforms**

- **Commercial effort**
- **To develop capability to track items across the global supply chain**

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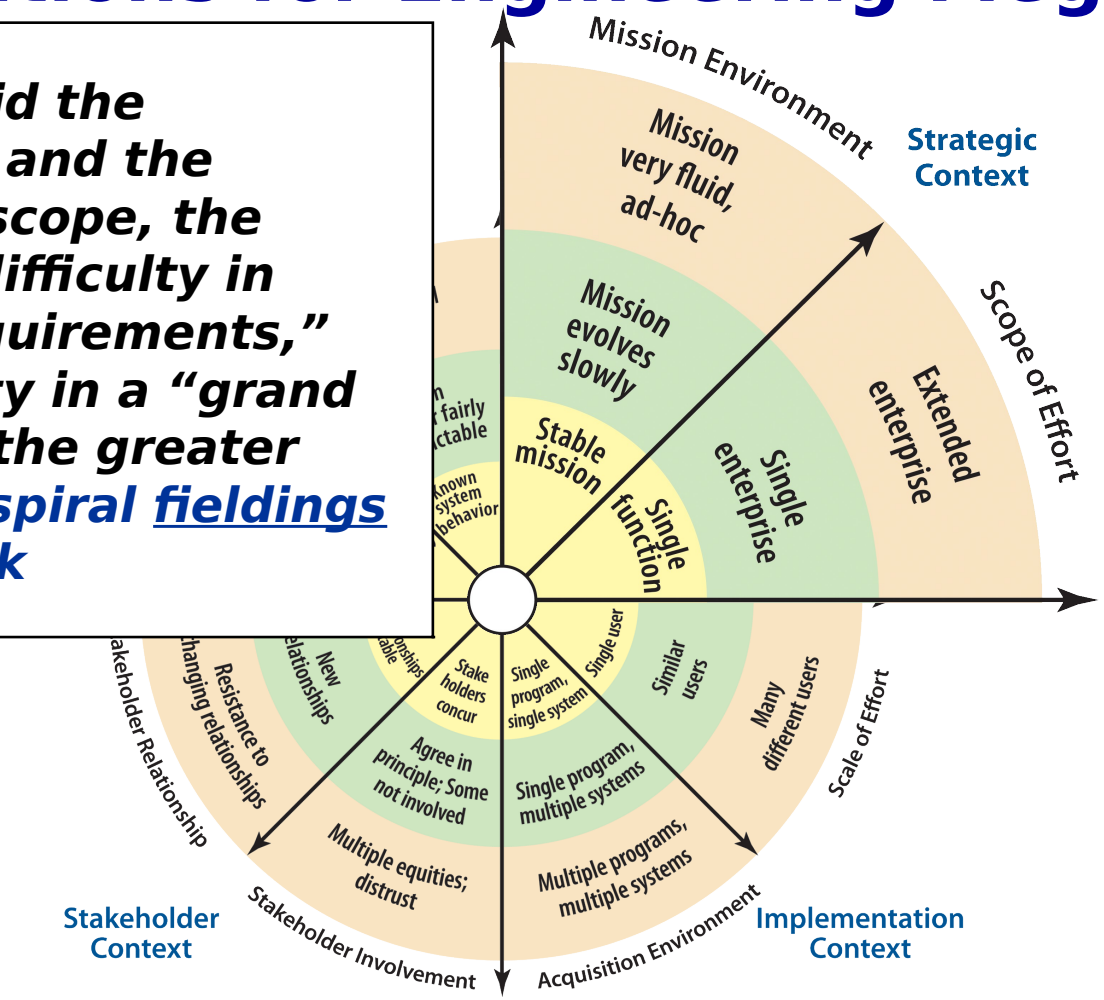
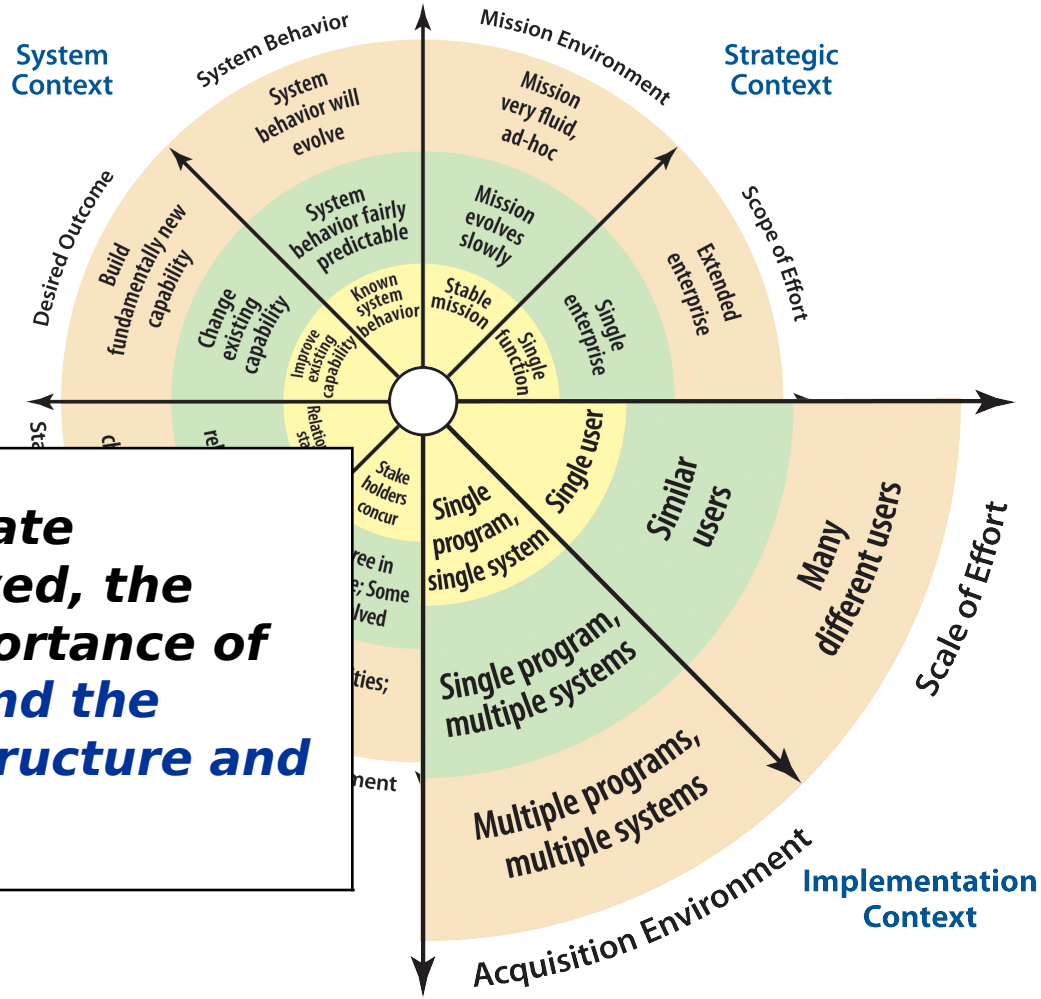
Implications for Engineering Mega-

The more fluid the environment and the broader the scope, the greater the difficulty in defining "requirements," the less utility in a "grand design" and the greater the value of spiral fieldings with feedback

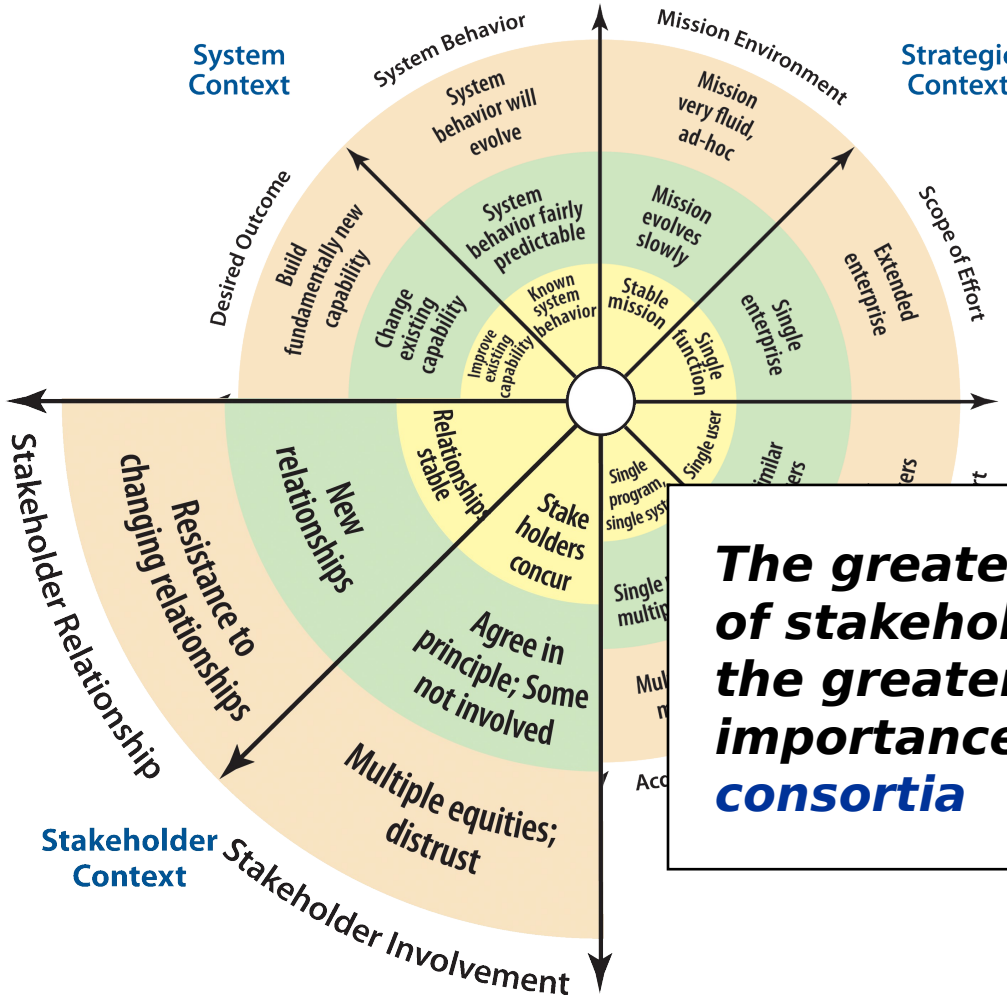


Implications for Engineering Mega-Systems



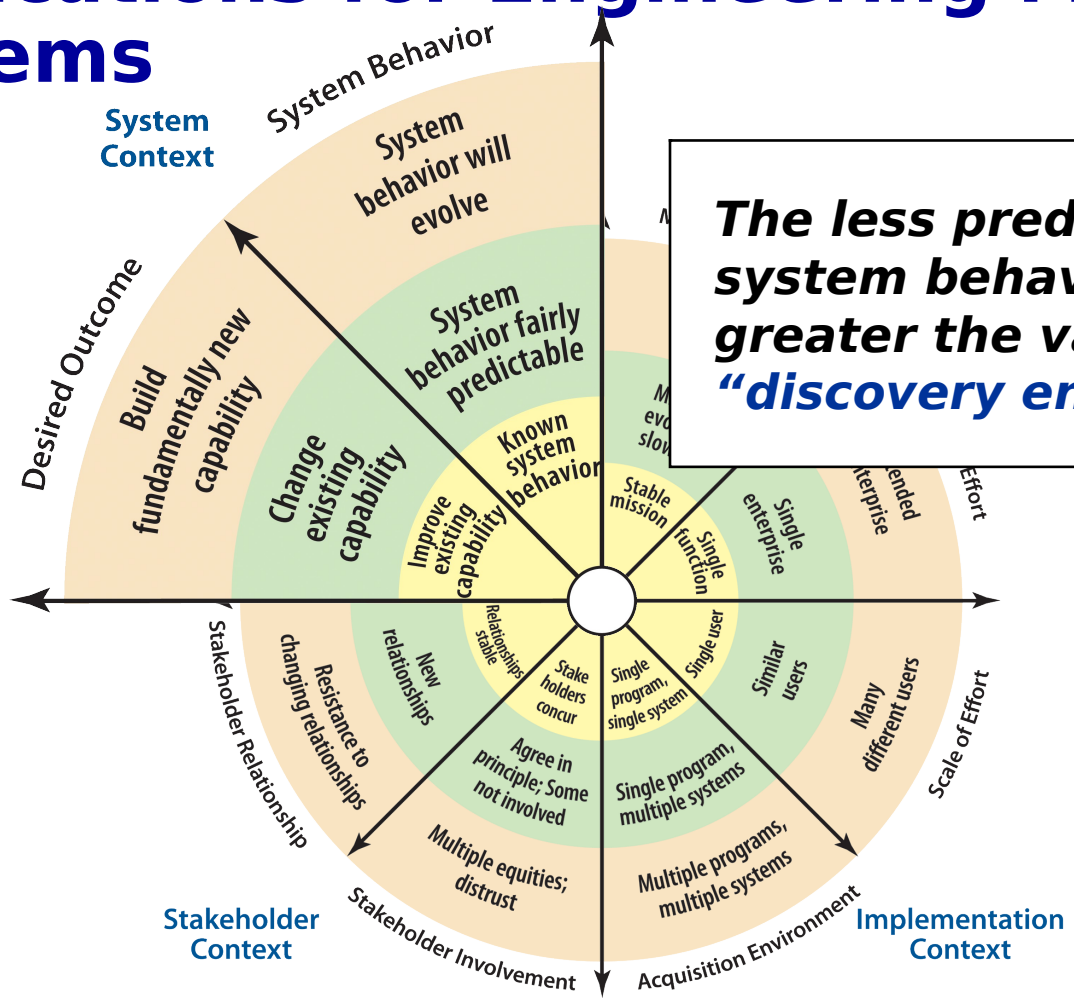
The more separate programs involved, the greater the importance of consensus around the enabling infrastructure and design tenets

Implications for Engineering Mega-Systems



The greater the number of stakeholders involved, the greater the importance of forging consortia

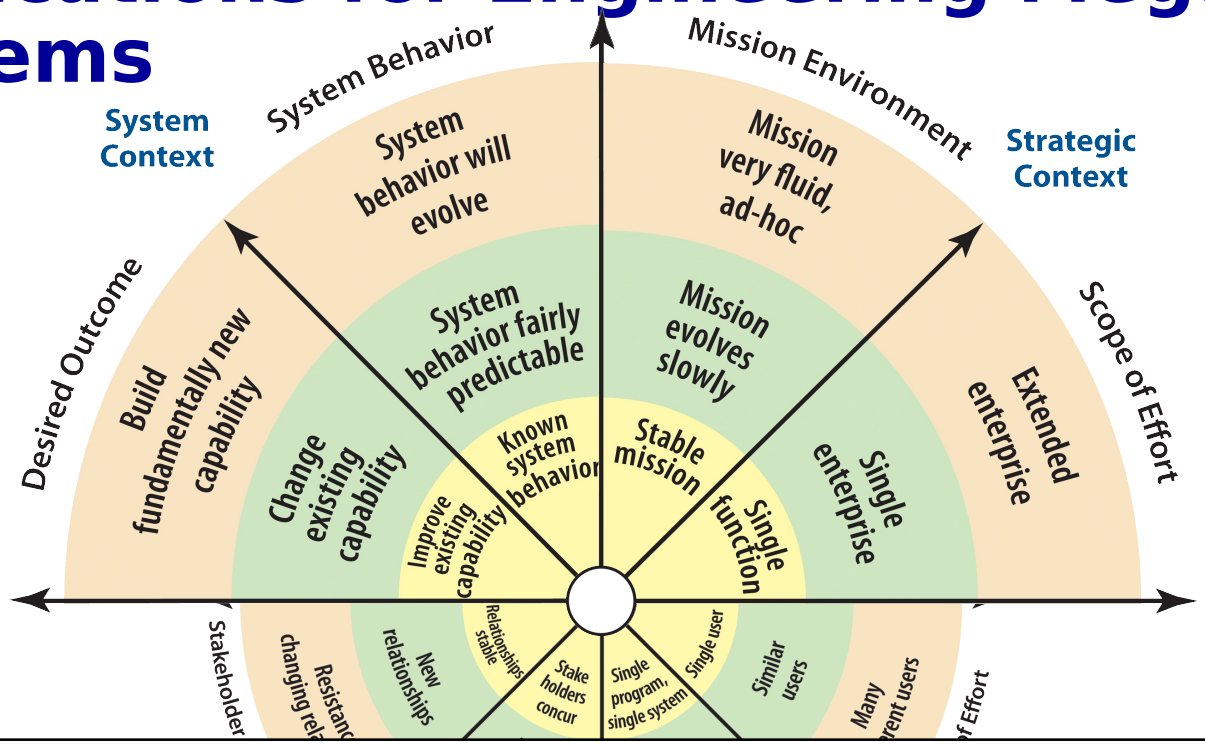
Implications for Engineering Mega-Systems



The less predictable the system behavior, the greater the value of "discovery engineering*"

* ***Prototyping, exploratory integration, field trials, experiments, pilots…***

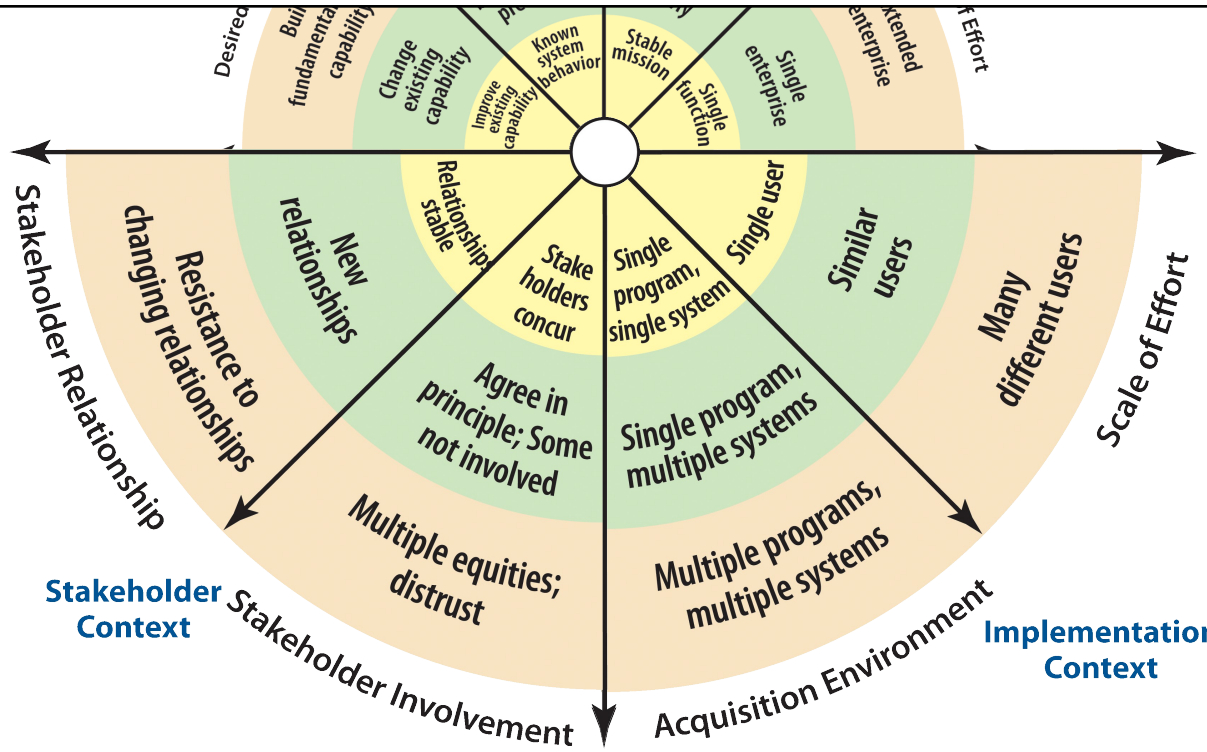
Implications for Engineering Mega-Systems



Traditional systems engineering focuses on managing execution risk; mega-systems engineering focuses on managing uncertainty

Implications for Engineering Mega-Systems

Traditional systems engineering integrates technical and business considerations, mega-systems engineering must also encompass political, organizational and economic dimensions



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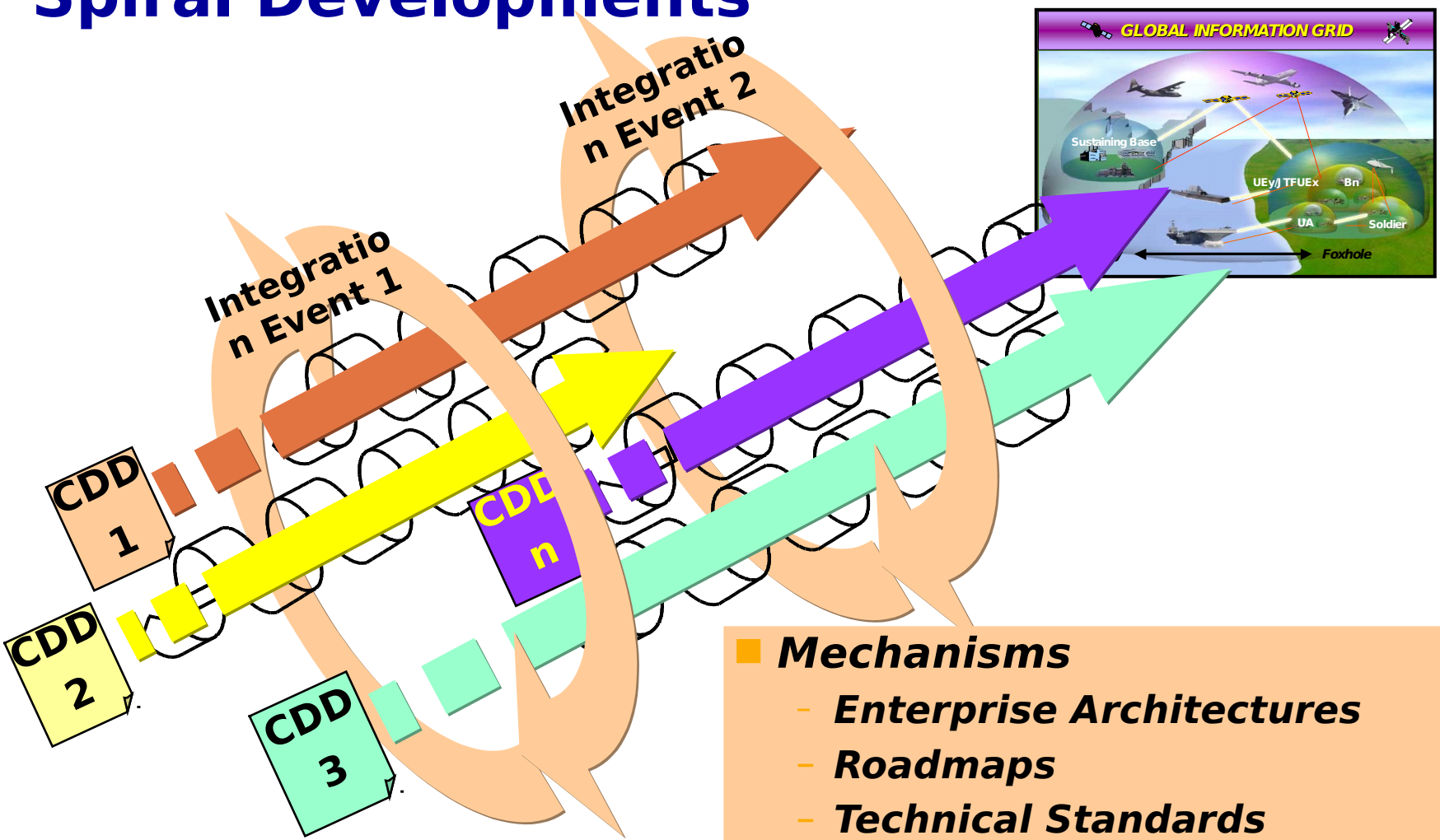
Moving to a Spiral Model

- ***Comparable to commercial new product development model***
  - ***Desired outcome space is clear but shape of final product may not be***
  - ***In near term build on what's ready and producible***
  - ***Provides opportunity to adjust to changing markets, technologies and expectations***
- ***But, natural tension with supporting processes (e.g., funding, oversight…)***

Managing Multiple Asynchronous Spiral Developments



- ***Mechanisms***
  - ***Enterprise Architectures***
  - ***Roadmaps***
  - ***Technical Standards***
  - ***Cross-Boundary Engineering***